PCT

WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 : F16B 19/10, B21K 1/60

A1

(11) International Publication Number: WO 99/64751

(43) International Publication Date: 16 December 1999 (16.12.99)

(21) International Application Number: PCT/GB99/01776

(22) International Filing Date: 4 June 1999 (04.06.99)

(30) Priority Data:
9812093.4 5 June 1998 (05.06.98) GB

(71) Applicant (*for all designated States except US*): TEXTRON FASTENING SYSTEMS LIMITED [GB/GB]; Mundells, Welwyn Garden City, Herts AL7 1EZ (GB).

(72) Inventor; and
(75) Inventor/Applicant (*for US only*): DENHAM, Keith [GB/GB]; 6 Old Forge Close, Welwyn Garden City, Hertfordshire AL7 1SR (GB).

(74) Agent: COATES, Ian, Harold; Sommerville & Rushton, 45 Grosvenor Road, St. Albans, Hertfordshire AL1 3AW (GB).

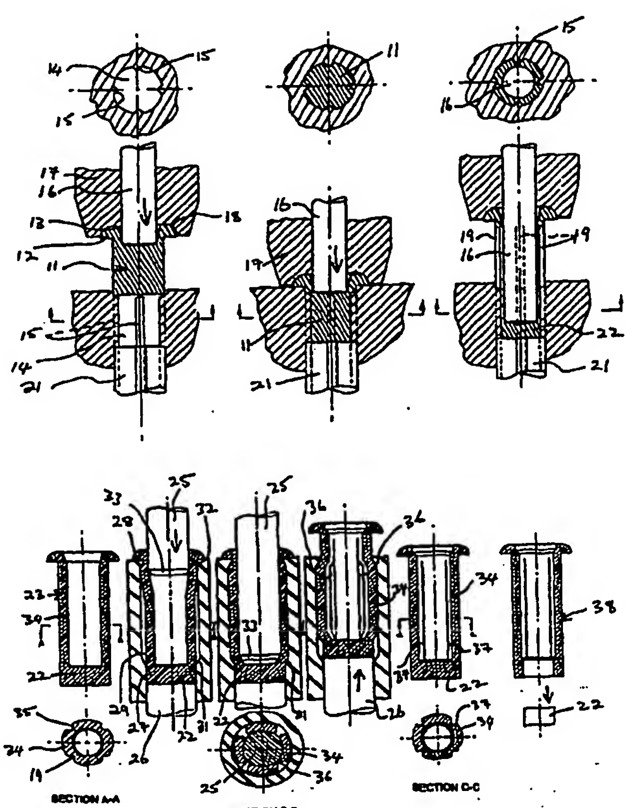
(81) Designated States: AE, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, UA, UG, US, UZ, VN, YU, ZA, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SL, SZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).

Published
With international search report.

(54) Title: METHOD OF FORMING A TUBULAR MEMBER

(57) Abstract

A method of forming a tubular member with longitudinal slots along part of its wall, comprising the steps of: firstly, forming longitudinal zones of weakness along part of the wall of the tubular member, and secondly, expanding the said part of the tubular member radially to cause fracture of the wall of the member along the longitudinal zones, thereby to form longitudinal slots.



FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AL	Albania	ES	Spain	LS	Lesotho	SI	Slovenia
AM	Armenia	FI	Finland	LT	Lithuania	SK	Slovakia
AT	Austria	FR	France	LU	Luxembourg	SN	Senegal
AU	Australia	GA	Gabon	LV	Latvia	SZ	Swaziland
AZ	Azerbaijan	GB	United Kingdom	MC	Monaco	TD	Chad
BA	Bosnia and Herzegovina	GE	Georgia	MD	Republic of Moldova	TG	Togo
BB	Barbados	GH	Ghana	MG	Madagascar	TJ	Tajikistan
BE	Belgium	GN	Guinea	MK	The former Yugoslav Republic of Macedonia	TM	Turkmenistan
BF	Burkina Faso	GR	Greece			TR	Turkey
BG	Bulgaria	HU	Hungary	ML	Mali	TT	Trinidad and Tobago
BJ	Benin	IE	Ireland	MN	Mongolia	UA	Ukraine
BR	Brazil	IL	Israel	MR	Mauritania	UG	Uganda
BY	Belarus	IS	Iceland	MW	Malawi	US	United States of America
CA	Canada	IT	Italy	MX	Mexico	UZ	Uzbekistan
CF	Central African Republic	JP	Japan	NE	Niger	VN	Viet Nam
CG	Congo	KE	Kenya	NL	Netherlands	YU	Yugoslavia
CH	Switzerland	KG	Kyrgyzstan	NO	Norway	ZW	Zimbabwe
CI	Côte d'Ivoire	KP	Democratic People's Republic of Korea	NZ	New Zealand		
CM	Cameroon			PL	Poland		
CN	China	KR	Republic of Korea	PT	Portugal		
CU	Cuba	KZ	Kazakstan	RO	Romania		
CZ	Czech Republic	LC	Saint Lucia	RU	Russian Federation		
DE	Germany	LI	Liechtenstein	SD	Sudan		
DK	Denmark	LK	Sri Lanka	SE	Sweden		
EE	Estonia	LR	Liberia	SG	Singapore		

METHOD OF FORMING A TUBULAR MEMBER

The invention relates to a method of forming a tubular member with longitudinal slots in its wall. By way of example, one such tubular member is the tubular shell of a blind breakstem rivet, of the type which is provided with multiple longitudinal slots so that, when the rivet is set by axially compressing part of the shell, the shell deforms into a number of outwardly projecting legs which provide a blind head having a relatively large radial dimension of engagement with the workpiece. Examples of such blind rivets with slotted shells are commercially available under the Registered Trade Marks BULBEX and TLR. However such longitudinally slotted members can be used for many other purposes.

The term 'slot' is intended to include both constructions in which there is a gap between the edges or walls of the parts of the material of the tubular member separated by the slot, and also constructions in which the two edges or walls of the slot are in contact with each other, there being a mechanical discontinuity in the material.

Such slotted members are usually of metal. With a relatively soft metal, such as aluminium, forming the slots in a tubular blank is commonly done by driving through the bore of the blank a close-fitting tool of much harder material, such as steel, which carries a number of radially projecting longitudinal ribs, each having a radial height equal to at least the wall thickness of the tubular blank. Each rib forms a corresponding longitudinal slot in the blank. However, if this method is applied to tubular blanks of steel, it is found that rapid and excessive wear to the tool, particularly to the leading ends of the ribs, occurs.

The present invention aims to provide a new method of forming a tubular member with longitudinal slots in its wall, which overcomes this problem.

Accordingly, the present invention provides, in one of its aspects, a method of forming a tubular member with slots along part of its wall, which method is set out in the accompanying claim 1.

Further features of the invention are set out in the accompanying claims 2 to 16. The invention includes a tubular member which has been formed by a method according to the invention, as set out in claim 16.

Some specific examples of the invention will now be described by way of example and with reference to the accompanying drawings, in which:-

Figures 1a to 1i show successive configurations of a blank during one example method;

Figures 2d to 2h correspond to Figures 1d to 1h respectively and illustrate a second example method which is a modification of the first example;

Figures 3d to 3h correspond to Figures 1d to 1h respectively and illustrate a third example method which is a different modification of the first example;

Figure 4 illustrates a blind rivet assembly incorporating a tubular shell made according to the invention; and

Figures 5a and 5b show the rivet of Figure 4 in the placed condition.

The term 'blank' is used to refer to the tubular member in all these successive configurations, apart from the finished product.

In Figures 1, 2 and 3 the blank is shown at least in longitudinal axial section, and in some Figures in cross-section as well, the cross-section being taken on the arrowed section line on the longitudinal section. In some Figures, the die in which the blank is contained, and a punch and/or ejector, is also shown.

In the examples, the blank is typically of low carbon steel and is designed to be used in the manufacture of a rivet shell of about 5 mm external diameter. Punches and dies used in the manufacturing processes are made of tool steel. The manufacturing

methods are performed using a progressive cold-heading machine, of the type commonly used to make such rivet shells and other items, and well known and understood by those skilled in the art.

Thus, referring first to Figure 1a, a blank 11 has been formed from a cylindrical slug cut from wire and has been formed with a head 12 and a tapering axial depression 13 at the head end. It is offered up to a die 14 which has a cylindrical in shape with four longitudinal ribs 15 spaced at 90° apart around the die. As illustrated in Fig 1a, the ribs are triangular in section with an included apex angle of 90° and a fairly sharp crest.

A punch is then driven into the depression 13 of the blank. The punch 16 is co-axial with a spring-loaded tool 17 which has an annular recess 18 on its leading end, to fit around the head of the blank. The punch and tool drive the blank into the die, as shown in Fig 1b, until the leading end of the blank contacts the bottom of the die (which is provided by the end face of an ejector pin 21), and the underside of the head of the blank contacts the face of the die. As illustrated in Figs 1b and 1c the diameter of the punch 16 is rather less than the diametrical distance between opposed crests of ribs 15. Continued movement of the punch 16 into the die 14 causes backwards extrusion of the material of the blank upwardly around the punch 16, the co-axial tool 17 rising against its spring-loading. The ribs 15 in the die 14 have formed longitudinal grooves 19 in the exterior face of the rearwardly extruded blank, as shown in Fig 1c. These grooves extend from near the underhead face of the blank to the remote end of the blank. The punch 16 is driven into the die only far enough that its leading end is spaced from the end wall of the die by a distance which leaves a thick web 22 at the end of the blank, as shown in Figures 1c and 1d.

The punch 16 and tool 17 are now withdrawn and the blank ejected from the die by the ejector 21. The blank is in the form shown in Fig 1d, and will now be referred to by the numeral 23. Most of the length of the blank comprises four full-thickness

longitudinal zones 34, joined each to the next by a thin longitudinal web 35, indicated in Fig 1d. The blank 23 is now inserted in the next die 24, as shown in Fig 1e (which also shows a punch 25 entering the blank 23). The die 24 has its lower end provided by the top face of an ejector pin 26. The inner end portion 27 of the die, adjacent the ejector 26, and the outer end portion 28 of the die 24, are of appropriate diameter to fit the exterior diameter of the blank 23. However, a lengthy intermediate portion 29 of the die is of larger diameter than the blank 23. This enlarged portion 29 merges to each of the smaller diameter end portions 27, 28 by a tapering portion 31, 32.

When the blank 23 has been fully inserted into the die 24 so that its bottom end contacts the ejector pin 26 and its underhead surface abuts the outer face of the die, the web 22 of the blank is contained within the inner end portion 27 of the die which is of a reduced diameter. A cylindrical punch 25 is driven into the blank. Fig 1e illustrates the start of this process. The punch has a main diameter greater than that of the bore of the blank 23, and has a chamfered leading edge 33 to facilitate its entry into the blank's bore. As the punch 25 progressively enters the die, it radially expands the blank 23. This has the effect of bursting apart the four full-thickness longitudinal zones 34 by breaking the four thin webs 35, at least over the majority of their lengths, to give four gaps 36 shown in Fig 1f. The material in the thin webs 35 is work hardened to a much greater extent than the other parts of the blank. This, together with the stress concentration in the webs, assists in their breaking. Fig 1f shows the fullest penetration of the punch 25 into the blank. The bottom end face of the punch is opposite the lower tapering portion 31 of the die, and is spaced slightly apart from the web portion 22 of the blank. The gaps do not extend to the web portion at the end of the blank. The ends of each gap 36 taper in width due to the effect of the tapering portions 31, 32 of the die.

The punch 25 is now withdrawn, and the ejector pin 26 is actuated to force the blank back out of the die 24. Figure 1g shows an intermediate stage in this action. As

the major part of the blank, in the form of the four longitudinal zones 34, is pushed through and past the tapered portion 32 and the reduced diameter outer portion 28 of the die, the four zones 34 are forced radially inwards, thus closing up the four longitudinal gaps 36. Fig 1h shows the form of the blank after this process has been completed. The edges of each adjacent pair of longitudinal zones 34 are in contact with each other adjacent the inner wall of the tubular member, with a slot 37 of effectively zero thickness (i.e. a physical discontinuity) between them, and a groove down the outside of the member.

The blank in the form shown in Fig 1h is then inserted in another die (not shown) where the web portion 22 at the end of the blank is removed by a suitable tool (not shown), as indicated schematically in Fig 1i. This leaves the fully manufactured tubular slotted member as illustrated at 38 in Fig 1i.

The man skilled in the art of progressive cold-heading will appreciate that, allowing for two dies to head and form the depression in the initial blank 11 in Fig 1a, the two dies 14 and 24, and the further die for removing the end web, this example manufacturing process can be carried out on a 5-station progressive cold header.

Fig 2 illustrates a modification of the example method described with reference to Fig 1. In Fig 2, Figs 2d to 2h respectively correspond to Figs 1d to 1h. For ease of comparison and understanding, identical parts are indicated by identical reference numerals, and corresponding parts are indicated by similar reference numerals with 100 added to the number.

The only difference of substance in this modification is that the die 124 has a slightly larger diameter mouth. This is apparent from Figs 2e & 2f, which show an annular gap 41 between the blank 23 and the outer portion 128 of the die adjacent its mouth. The effect of this is that, when the blank is ejected, its radially enlarged part is reduced to a diameter slightly larger than its original size. Consequently, the four

longitudinal parts 134 are not in edge-to-edge contact with each other, but are separated by narrow gaps 137, as shown in Fig 2h.

A further example is illustrated in Figs 3d to 3h, which also correspond respectively to Figs 1d to 1h. Again, identical parts are given identical reference numerals, and corresponding parts by similar reference numerals with 200 added. This is also a modification of that first example method, but is a greater modification than the one just described.

In this example, the tubular blank 223 before radial expansion has, effectively, four equally spaced longitudinal grooves 219 along its inner face. The bore of the blank is in fact square in section as illustrated in Fig 3d. This is achieved by using a die and punch which are a modification of those illustrated in Fig 1. The die will be cylindrical in section, and the punch square in section. The man skilled in the art of cold forming will readily understand how to design such a die and punch, which are the inverse of those of Fig 1. The other difference is that the blank made in this form has a bore extending completely through it, with no web across the end, although the corresponding tail end portion may be thickened as at 222 in Fig 3d.

The radial expansion of the blank is by means of a die 224 and punch 225. The punch 225 has its end part 44 of reduced diameter, which fits inside the far end part of the blank bore where, in Figs 1 & 2, the web portion 22 was. This radial expansion of the blank, and its subsequent reduction in diameter on ejection from the die, are substantially identical to those described in the first example method with reference to Fig 1. The only substantial difference in the finished manufactured tubular member 238 is that it has its four longitudinal parts 234 separated by longitudinal internal grooves each of which leads to a zero-thickness slot 237 adjacent the outside of the tubular member. There is no web at the end of the tubular member to be removed. Thus this manufacturing process can be carried out on a 4-station header.

Fig 4 illustrates how a tubular member such as 38, 138 or 238 is used in a blind rivet, assembled on a stem 41 having a stem head 42. When the rivet is placed, by axially compressing the shell 38, 138 or 238, the shell parts at the four slots 37, 137 or 237, to form four outwardly folded legs 43, as shown in Fig 5.

The configuration of the tubular member 138 illustrated in Fig 2h is particularly advantageous for use as a blind rivet shell. The fact that an intermediate length of the shell has its outer surface radially outwardly offset with respect to its ends promotes initial buckling of the shell under axial compression.

The invention is not restricted to the details of the foregoing examples. A slotted tubular member may be utilised for any convenient purpose, other than a blind rivet shell.

A combination of both internal and external grooves could be used.

CLAIMS

1. A method of forming a tubular member with longitudinal slots along part of its wall, comprising the steps of:

firstly, forming longitudinal zones of weakness along part of the wall of the tubular member, and

secondly, expanding the said part of the tubular member radially to cause fracture of the wall of the member along the longitudinal zones, thereby to form longitudinal slots.

2. A method as claimed in claim 1, further comprising the step of, thirdly, radially compressing the tubular member.

3. A method as claimed in claim 2, in which the third step comprises radially compressing the tubular member until the edges or walls of at least part of the length of each slot are in contact with each other.

4. A method as claimed in claim 2, in which the third step comprises compressing the tubular member so that edges or walls of at least part of each slot move nearer to each other but do not contact each other.

5. A method as claimed in claim 1, in which radial expansion of the tubular member is achieved by driving axially into its bore a pin of larger diameter than the bore.

6. A method as claimed in claim 1, in which radial expansion of the tubular member is achieved by locating it within a die cavity having part of its length, corresponding to the aforesaid part of the tubular member, of a diameter corresponding to the desired enlarged diameter of the tubular member, and driving axially into the bore of the tubular member a pin of larger diameter than the bore, and in which the die is provided with at least one other part of its length of reduced diameter.

7. A method as claimed in claim 6, in which radial compression of the thus radially expanded tubular member is achieved by axially forcing the expanded part of the tubular member through a part of the die of reduced diameter.

8. A method as claimed in claim 1, in which the longitudinal zones of weakness are provided by longitudinal grooves along the inner surface of the wall of the tubular member.

9. A method as claimed in claim 1, in which the longitudinal zones of weakness are provided by longitudinal grooves along the outer surface of the wall of the tubular member.

10. A method as claimed in claim 1, in which the longitudinal zones of weakness are provided by longitudinal grooves along the inner surface, and longitudinal grooves along the outer surface, of the tubular member.

11. A method as claimed in any of claims 8, 9 and 10, in which the forming of the aforesaid longitudinal grooves takes place in the same operation as the forming of the bore of the tubular member.

12. A method as claimed in claim 11, in which the forming of the grooves is achieved by backwards extrusion.

13. A method as claimed in any of the preceding claims, in which the tubular member is initially formed with its bore stopping short of one end of the member, the bore being opened at that end of the member in a subsequent operation.

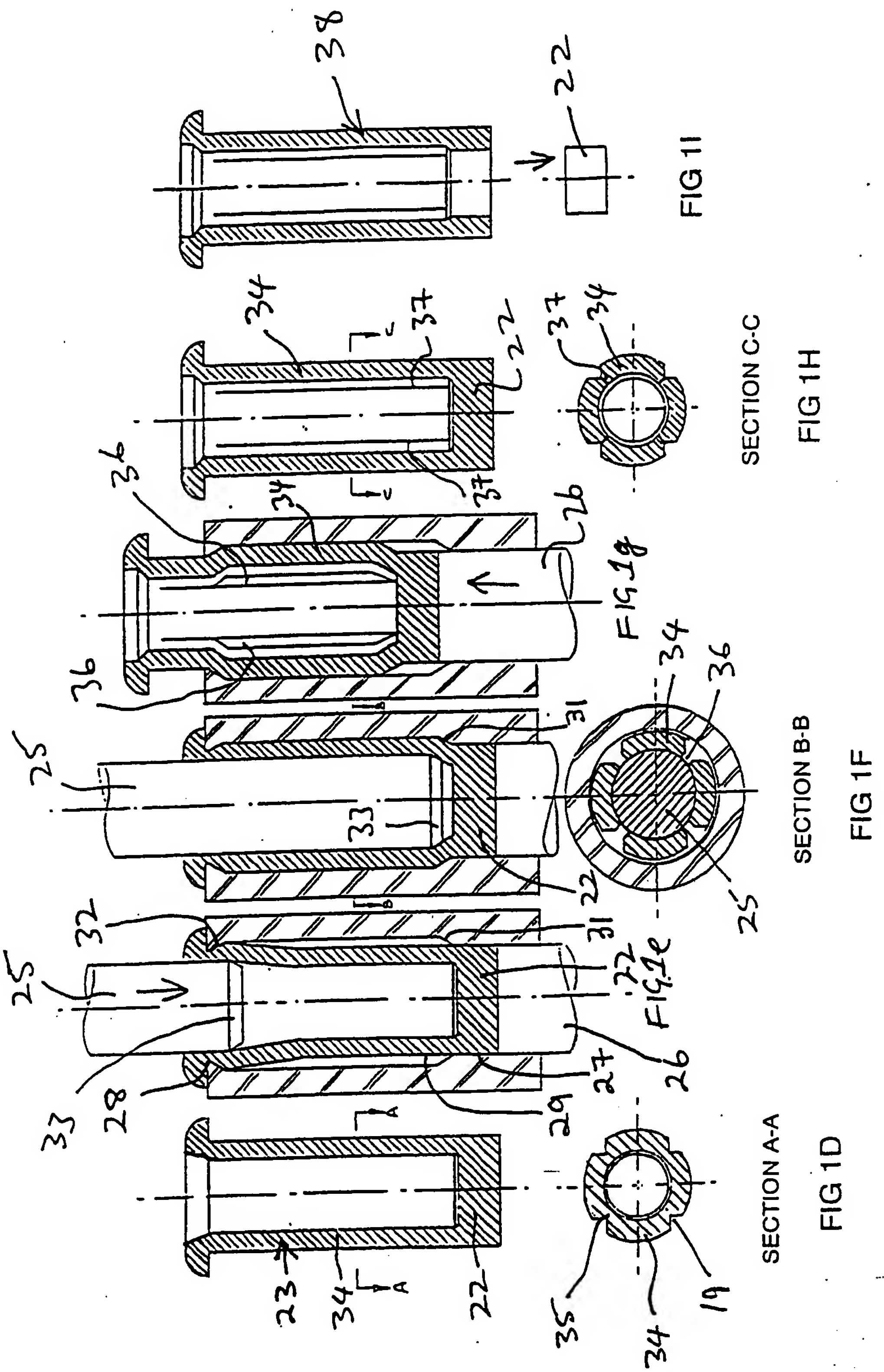
14. A method as claimed in any of claims 1 to 12, in which the tubular member is initially formed with its bore extending completely throughout its length.

15. A method of forming a tubular member, which method is substantially as hereinbefore described with reference to, and illustrated in, the accompanying drawings.

16. A tubular member which has been formed by a method as claimed in any of the preceding claims.

WO 99/64751 PCT/GB99/01776

1/5



2/5

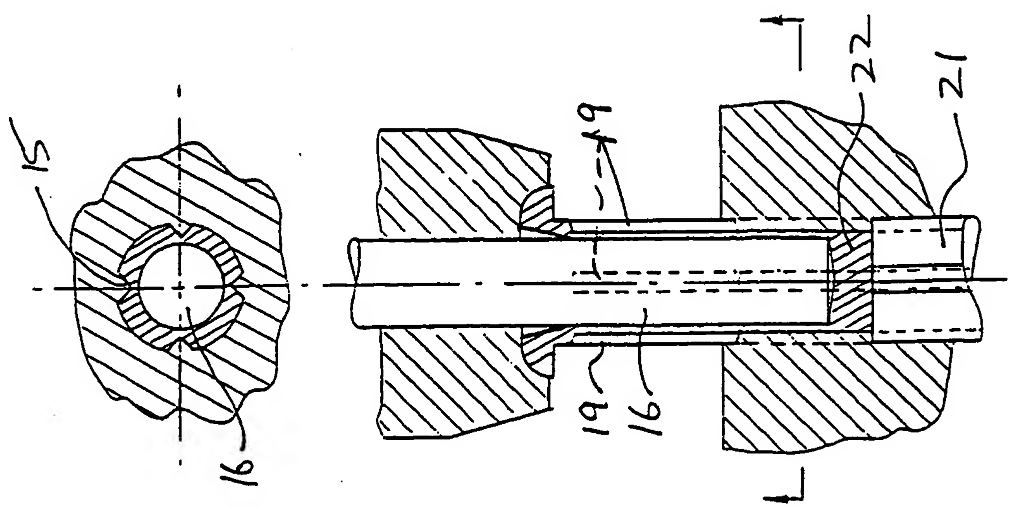


FIG.1c

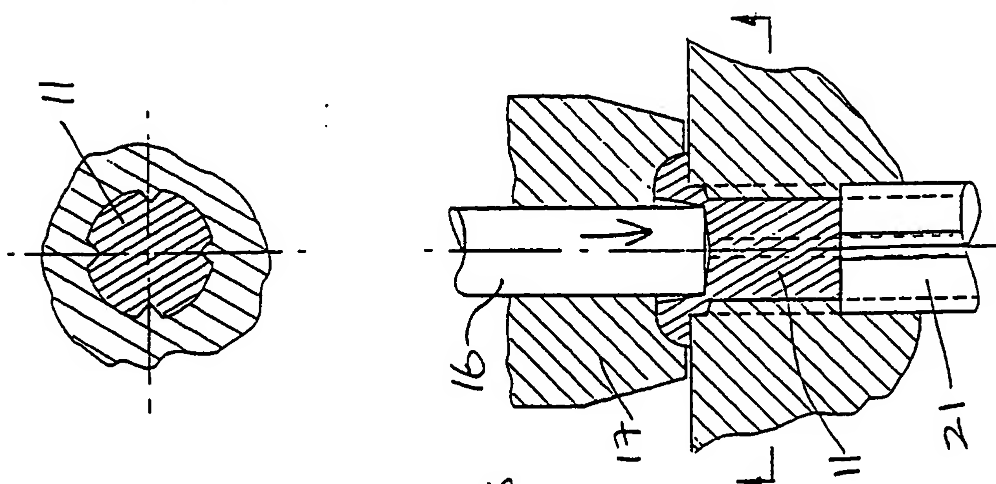


FIG.1b

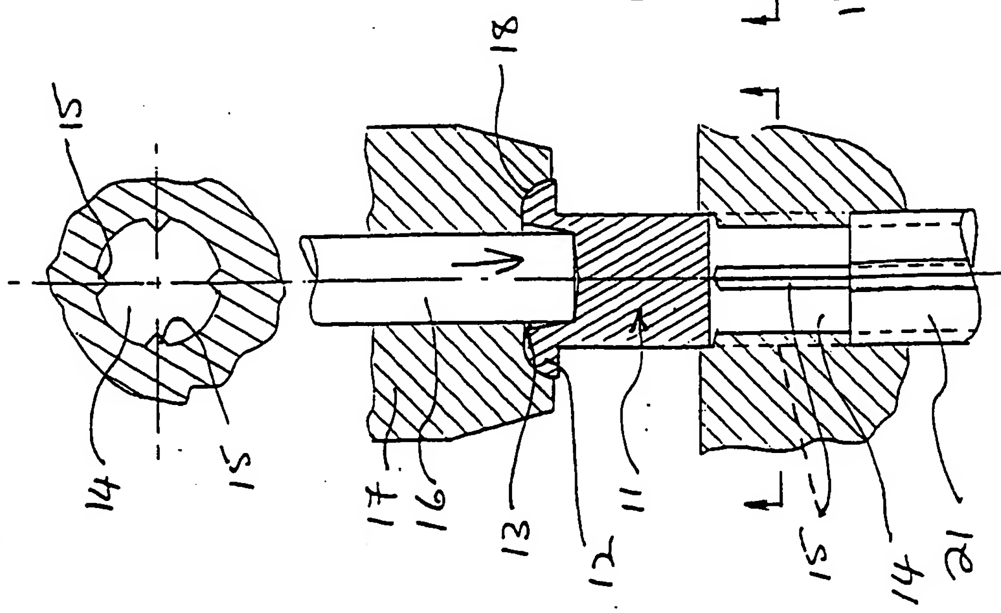
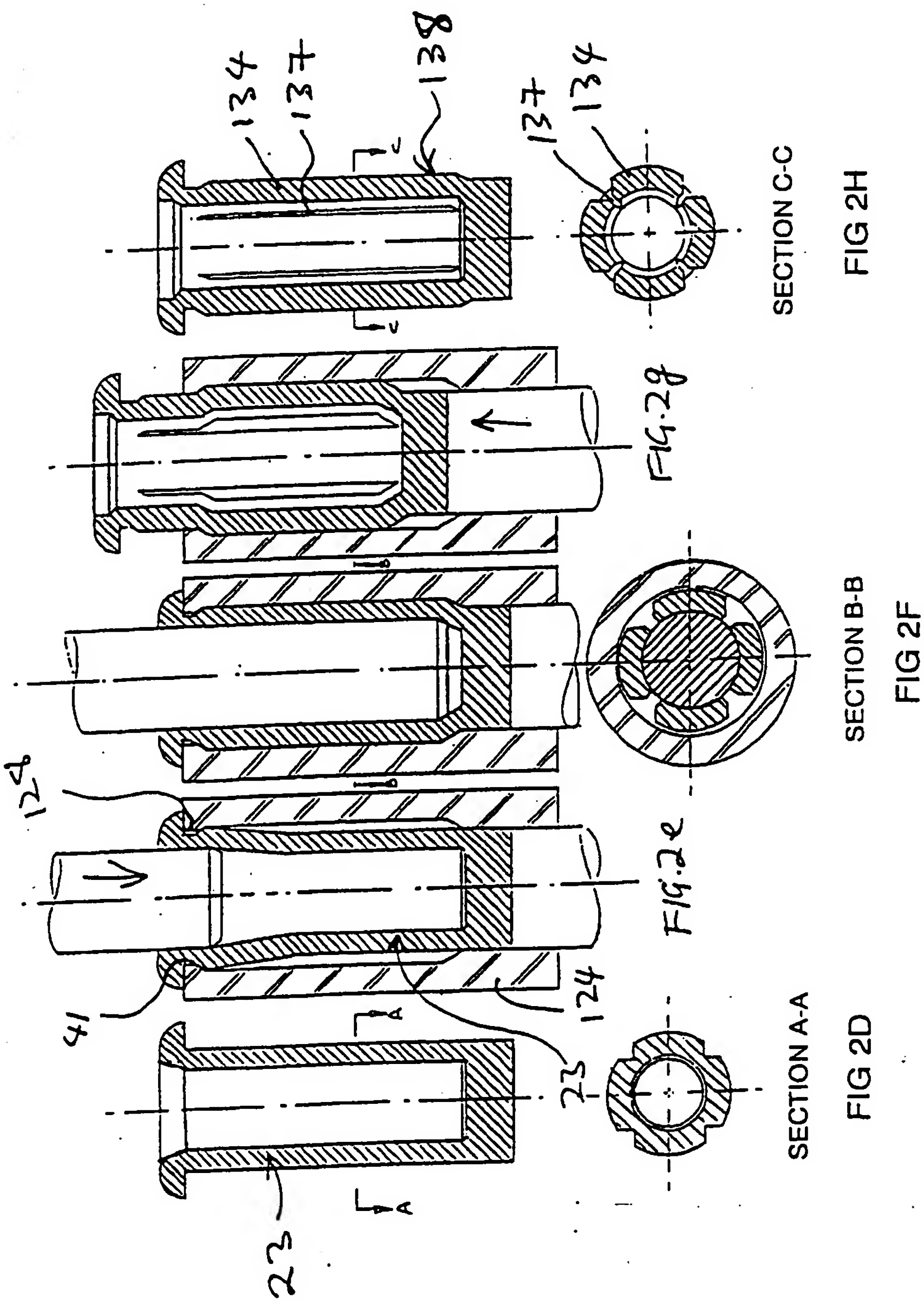
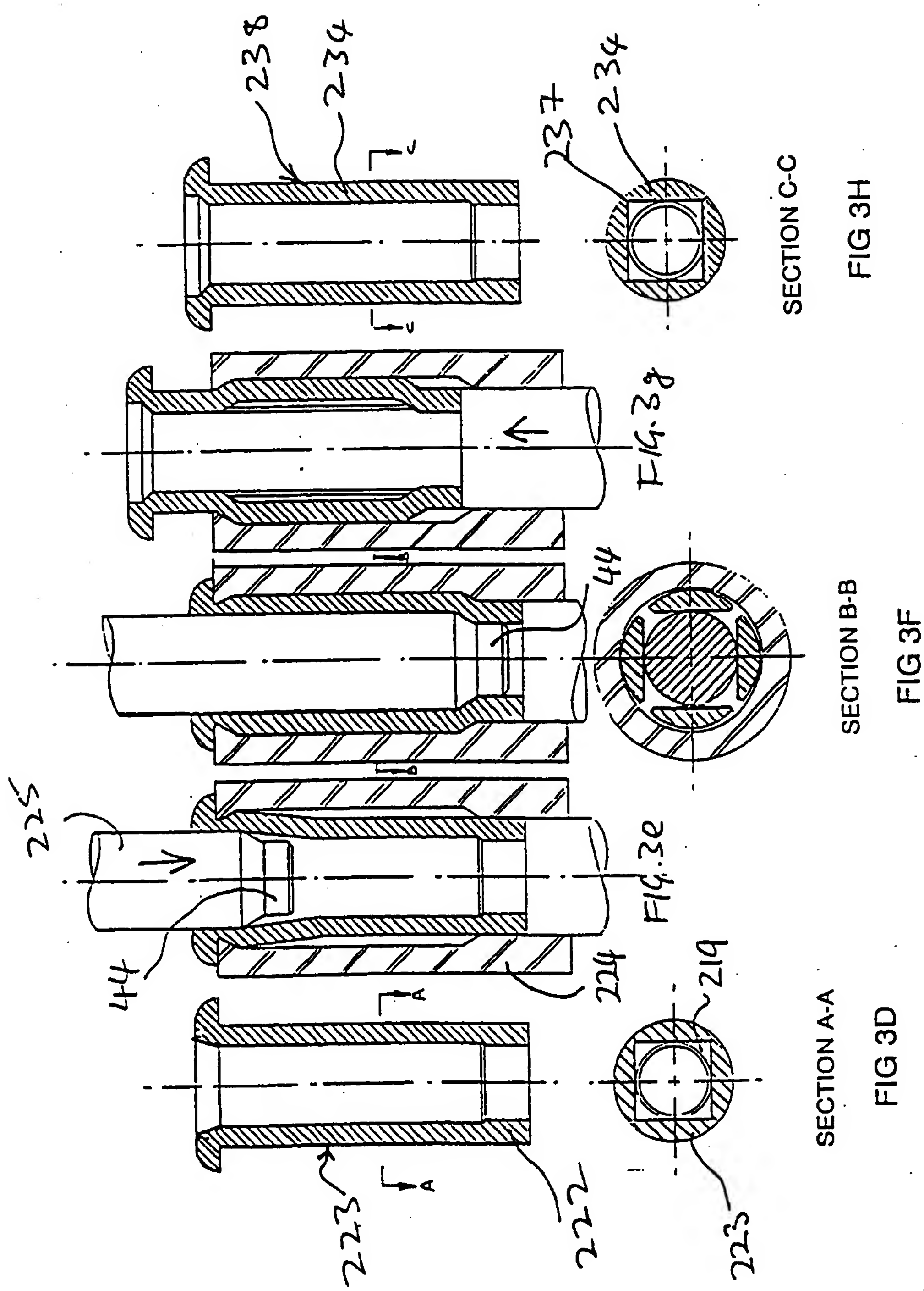


FIG.1a

WO 99/64751 PCT/GB99/01776

3/5





SECTION C-C
FIG 3H

SECTION B-B
FIG 3F

SECTION A-A
FIG 3D

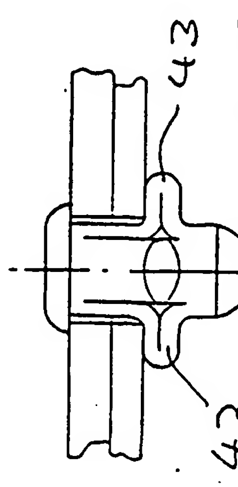


FIG.5a

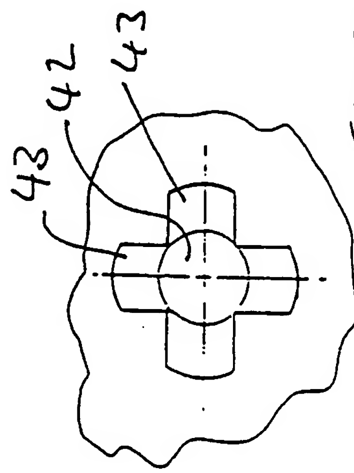


FIG.5b

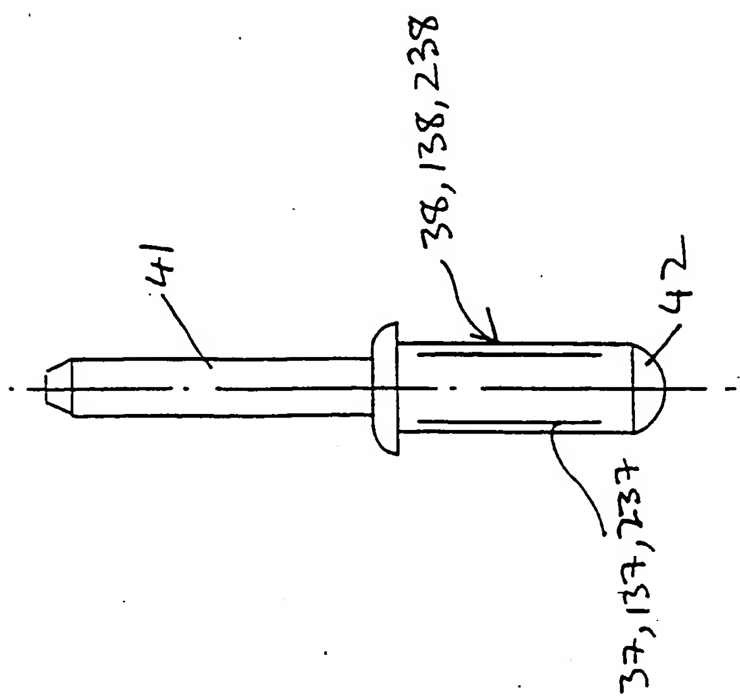


FIG.4

INTERNATIONAL SEARCH REPORT

Inte· ·nal Application No
PCT/GB 99/01776

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 F16B19/10 B21K1/60

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 F16B B21K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 0 328 314 A (AVDEL SYSTEMS LTD) 16 August 1989 (1989-08-16)	1,5,8,16
A	claims 1,4-6; figures 1,2,4,5	2-4,6,7, 9-15
X	EP 0 631 831 A (SCHRUFF HERBERTS) 4 January 1995 (1995-01-04)	1,9,14, 16
A	figures 1-10	2-8, 10-13,15
X	US 4 708 553 A (BRAYCHAK JOSEPH J ET AL) 24 November 1987 (1987-11-24)	1,5,16
A	the whole document	2-4,6-15
X	US 4 580 936 A (FRANCIS ALBERT C ET AL) 8 April 1986 (1986-04-08)	1,5,16
A	column 5, line 64 - column 6, line 3; claim 2; figure 1	2-4,7-15

-/--

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
18 August 1999	06/09/1999

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Huusom, C

2

INTERNATIONAL SEARCH REPORT

International Application No
PCT/GB 99/01776

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	EP 0 162 647 A (TUCKER FASTENERS LTD) 27 November 1985 (1985-11-27) figures 1-23	1-15

2

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/GB 99/01776

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 0328314 A	16-08-1989	AT 79167 T	15-08-1992
		AU 2985889 A	17-08-1989
		CA 1310208 A	17-11-1992
		GB 2215800 A	27-09-1989
		JP 1939853 C	09-06-1995
		JP 2021011 A	24-01-1990
		JP 6063532 B	22-08-1994
		US 4897003 A	30-01-1990
EP 0631831 A	04-01-1995	DE 4321174 A	05-01-1995
		AT 165026 T	15-05-1998
		DE 59405681 D	20-05-1998
US 4708553 A	24-11-1987	AU 569327 B	28-01-1988
		AU 3368084 A	04-04-1985
		CA 1253017 A	25-04-1989
		DE 3435587 A	18-04-1985
		FR 2552830 A	05-04-1985
		GB 2147385 A,B	09-05-1985
		IT 1175760 B	15-07-1987
		JP 60091007 A	22-05-1985
US 4580936 A	08-04-1986	GB 2136075 A	12-09-1984
		AU 564123 B	30-07-1987
		AU 2527084 A	13-09-1984
		CA 1244269 A	08-11-1988
		DE 3407464 A	13-09-1984
		FR 2542396 A	14-09-1984
		IT 1180686 B	23-09-1987
		JP 1665803 C	29-05-1992
		JP 3031922 B	09-05-1991
		JP 59166708 A	20-09-1984
EP 0162647 A	27-11-1985	GB 2158754 A	20-11-1985
		AU 577376 B	22-09-1988
		AU 4268685 A	21-11-1985
		CA 1268323 A	01-05-1990
		DE 3583770 A	19-09-1991
		JP 1833719 C	29-03-1994
		JP 61046342 A	06-03-1986
		US 4586231 A	06-05-1986